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Development of Audit Devices and Materials for Source Level Air Pollution Measurement Methods

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Research Triangle Park, NC

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Development of Audit Devices and Materials for Source Level Air Pollution Measurement Methods

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16. ABSTRACT

This paper describes the procedures followed by the U. S. Environmental Protection Agency (EPA), Quality Assurance Division, when developing a source level audit device or material (d/m). These audit d/m's are used to quantitatively determine that an EPA reference method is being properly performed by an analyst. The procedure to develop an audit d/m is described by discussing the development of an audit material for EPA reference Method 5, Determination of Particulate Emissions from Stationary Sources. The paper also presents a list of all audit d/m's currently available from the EPA Quality Assurance Division.

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INTRODUCTION

The U. S. Environmental Protection Agency (EPA) has promulgated over 50 test methods for use in enforcing the New Source Performance Standards and National Emissions Standards for Hazardous Air Pollutants. The EPA also has introduced several guideline methods for the measurement of toxic air pollutants from stationary sources. Many of these emission measurement methods require or recommend that the tester participate in the EPA performance audit program. This article provides the background on the procedures used to develop many of the audit materials used in the EPA audit program for stationary sources. Also, this article 1) provides the users of these performance audits with a better understanding of the use of the audits, 2) should help state agency personnel to develop audit materials for their test methods or to modify the EPA audit materials to better accomplish the State agency goals, and 3) should help industrial groups to develop their own audit materials. The audit materials addressed in this paper include solids and liquids; the development of audit materials in compressed gas cylinders follows a similar procedure, but will not be discussed. A listing of all audit materials presently available through the U. S. EPA is included at the end of the discussion.

OBJECTIVES, GOALS, AND PRINCIPLES OF DEVELOPMENT FOR AUDIT MATERIALS

The objective of a performance audit is to determine quantitatively if the measurement system is in control. The measurement system may pertain to sample collection and/or sample analysis. Typically, for source method audits, an acceptable audit value range is assigned to the performance audit. This acceptable audit value range is set at a level that should be achieved by a tester who correctly follows the procedures of the method. The audit value range reflects the accuracy of the method when the procedures are followed; in other words, a tester who correctly follows the method should not fail to achieve the required audit value range as a result of method error only.

The goal of any quality assurance program is to improve data quality by providing the tester with feedback indicating when he is not properly executing the method. From historical audit data, it appears that data quality does improve with time among laboratories that routinely participate in performance audits. As an example, Figure 1 shows Method 6 (SO_2) audit data over the past ten years.

A stationary source performance audit material used in the EPA audit program typically must comply with the following criteria:

1) The audit value (amount or concentration of the audit material) must be accurately known. Typically, this means that the stated value is within 3% of the true value.

2) The stated audit value must remain stable until the time of the audit.

3) The audit material value must be in the appropriate measurement range; e.g., for compliance test methods, the audit values are generally within 50 to 200% of the EPA emission standard.

4) The acceptable audit value limits must reflect the accuracy of the method when the method is correctly executed.

5) The audit material must be simple to use and compatible with the test method equipment and procedures.

6) To the extent possible, the audit program must be cost effective.

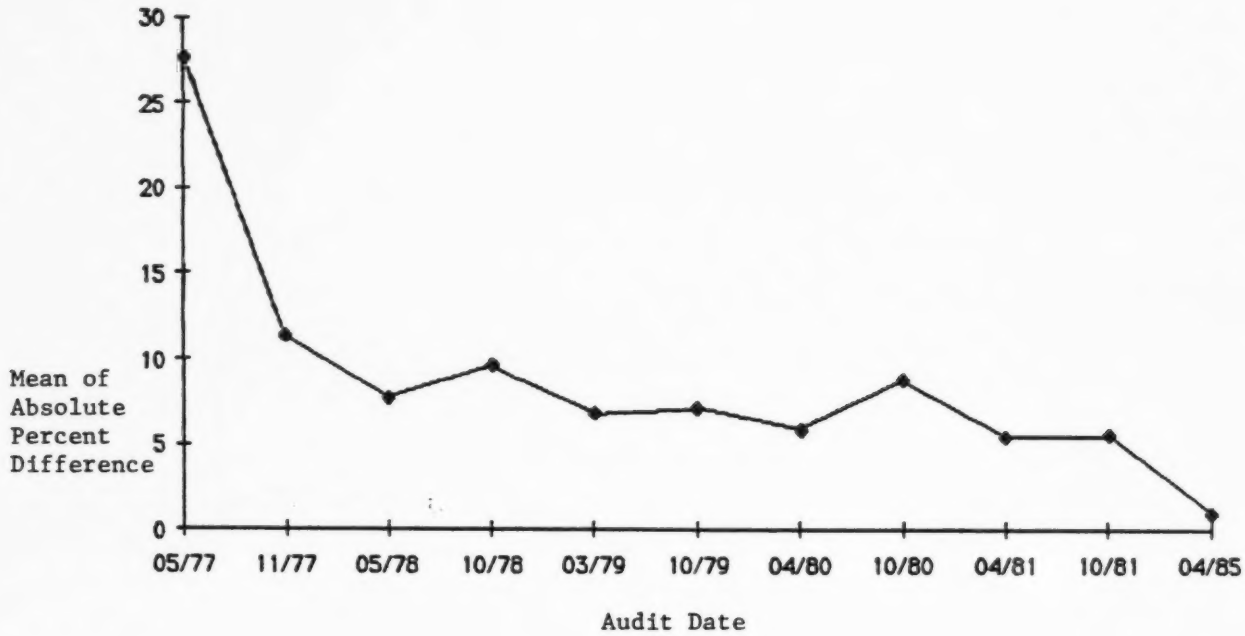

Figure 1. Average absolute percent difference of Method 6 (SO_2) audit data over past 10 years.

As written, EPA stationary source test methods have either eliminated all major interferences, or include warnings regarding the interferences. In addition, they include specific criteria for all equipment and materials used in both the sampling and analytical procedures. This ensures that there are no matrix effects and interferences in either the sample collection or analysis when they are used on specified regulated sources. Thus, the EPA performance audits generally need only to assess the ability of the equipment and measurement personnel to meet the equipment criteria and follow the method's procedures. It is, therefore, not necessary to subject the audit material to the sample matrix under normal circumstances. However, when an EPA audit material is used for a source other than one for which the audit was developed, the user must take care to ensure that it is suitable for this other purpose.

FOUR PHASE DEVELOPMENT PROGRAM

The development and evaluation of the source audit material is accomplished in a four phase program. The phases are 1) the initial development and laboratory evaluation, 2) single laboratory field use, 3) interlaboratory field use, and 4) field use by the source sampling community.

To facilitate the explanation of the four phase development program, an example of the procedures used in the development of the EPA Method 5 audit material will be integrated into the following discussion. Development of the Method 5 audit material has been completed through three of the four phases. The fourth phase will be completed over the next several months.

PHASE I - INITIAL DEVELOPMENT AND LABORATORY EVALUATION

In the first phase of the development program, both the objectives and the approach to achieve them must be clearly defined. The objectives for the Method 5 audit material were:

1) To construct a prototype that has the potential to become a suitable audit material, and where applicable, yield the mass or concentration of sample that represents the amount of sample collected at the emission limit for the applicable EPA emission standards.

2) To design an audit material that is inexpensive, easy to use, and lends itself to shipment through a common, commerical carrier.

3) To ensure that the true value of the audit material can be accurately determined, and to perform an intralaboratory test on the prototype audit material to show that is has acceptable accuracy (as measured by the percent recovery).

This was accomplished as follows:

An audit container was designed that would hold a known amount of particulate matter that could be quantitatively removed from the container and discharged into the sampling train. In selecting the material of construction for the container, both the effect of static charge on particulate matter and the need for an extremely smooth inside surface were considered important. Three designs of glass containers were constructed and investigated. The final design selected for the container was simple to clean, allowed for easy transfer of the audit material to the standard Method 5 nozzle, and fit a commercially available shipping container.

Similarly, the particulate matter had to have an accurately known audit value. Three audit materials (glass beads, stainless steel beads, and NBS fly ash Standard Reference Material 1633)) were selected for initial evaluation. The particulate matter size distribution of these materials was in the range of 10 to 20 μm mass mean diameter.

Each type of particulate matter was then investigated to determine its potential recovery efficiency as follows. Known amounts of each material were placed into a prototype audit container and the contents were then poured into a tared beaker. The interior surface of each container then was rinsed with acetone, which was also added to the same beaker. The beaker contents were then taken to dryness and the weight gain (% recovery) was determined. As shown in Table I, the results of each of four tests on the three materials all met the objective of being within 3 percent of the audit value.

Based on these simple tests, stainless steel was selected as the audit material, but later tests using the Method 5 equipment showed that the majority of the stainless steel particulate matter was collected in the sampling probe and not on the filter. Also, the stainless steel beads did not adhere well to the filter after collection. As a result, the distribution of the stainless steel beads was not considered representative of the typical distribution of particulate matter within a sampling train. A second audit material, the NBS flyash, was then similarly evaluated and found satisfactory. Use of this material would provide not only for auditing Method 5 samples, but also would provide the possibility of auditing samples for trace metals (i.e., chromium, nickel, and cadmium), since this material has NBS certified trace metals analysis.

To ensure that the amount of audit material to be used would be in the proper range, calculations were performed to determine the amount of particulate matter that would be collected when sampling plants operating near the emission limits for the EPA emission standards. This amount was approximately 75 to 125 milligrams, depending on the standard and the sampling time. The audit value range was then set to cover this range and values slightly higher (75 to 225 mg), to accomodate State Implementation Plan (SIP) standards. This range of values was also selected to ensure that audit values would meet the criteria of being in the desired range of 50 to 200% of the emission standard.

The cost to prepare the Method 5 material, including the protective shipping container, was kept under $10 per device since more than 100 of the audit devices would be required for national use.

For the completion of the Phase I intralaboratory evaluation, three sample weights were selected (nominally 75 mg, 125 mg, and 225 mg). Two other variables (probe length and sample rate) were considered as having the potential to affect the audit recovery. As a result, three probe lengths (4 ft, 6 ft, and 8 ft), and three sampling rates (0.5 cfm, 0.75 cfm, and 1.0 cfm) were used in the evaluation creating a 3 by 3 by 3 matrix. To test all possible combinations, 27 runs were conducted in the laboratory. The recovery results for all runs were within 10 percent of the audit value with an average recovery of 101.5 percent (Table II), with the exception of Run Nos. 3 and 6 in which the 8-foot probe was used. It was discovered later that this probe had not been properly cleaned prior to the test. The average absolute percent difference was greater than anticipated, but was believed to be related to method error and not to audit device error.

Table I. Recovery of Particulate Audit Material From Prototype Audit Device.

Run No.	Sample No.	Sample Weight (mg)	Sample Recovered From Audit Device (Container) (mg)	Recovery (%)	Sample Recovered From Rinse (mg)	Rinse Recovery (%)	Total Sample Recovered (mg)	Total Recovery (%)
1	glass	128.6	126.1	98.1	3.5	2.7	129.6	100.8
2	glass	137.2	134.0	97.7	5.6	4.1	139.6	101.7
3	glass	287.4	282.6	98.3	1.7	0.6	284.3	98.9
4	glass	423.2	420.0	99.2	1.3	0.3	421.3	99.5
5	s.s. steel	73.8	72.1	97.7	0.4	0.5	72.5	98.2
6	s.s. steel	123.1	119.3	96.9	2.5	2.0	121.8	98.9
7	s.s. steel	221.2	216.9	98.1	2.3	1.0	219.2	99.1
8	s.s. steel	388.3	377.8	97.3	6.5	1.7	384.3	99.0
9	fly ash	84.0	81.3	96.8	2.3	2.7	83.6	99.5
10	fly ash	155.4	153.4	98.7	1.6	1.0	155.0	99.7
11	fly ash	249.8	247.3	99.0	4.6	1.8	251.9	100.8
12	fly ash	64.3	62.1	96.6	1.7	2.6	63.8	99.2

Table II. Recovery Efficiencies for Method 5 Audit Device Charged With Fly Ash Audit Material.

Run No.	Audit Sample Weight (mg)	Flow Rate (cfm)	Probe Length (ft)	Combined Weight (mg)	Relative Difference (mg)	Percent Difference	Recovery Efficiency (%)
1	75.5	0.5	4	75.3	- 0.2	-0.3	99.7
2	71.9	0.5	6	74.3	2.4	3.3	103.3
3	76.9	0.5	8	108.4	31.5*	41.0	141.0*
4	89.0	0.75	4	83.4	- 5.6	-6.3	93.7
5	72.8	0.75	6	75.5	2.7	3.7	103.7
6	74.2	0.75	8	96.5	22.3*	30.1	130.1*
7	83.6	1.0	4	83.0	- 0.6	-0.7	99.3
8	66.6	1.0	6	61.9	- 4.7	-7.1	92.9
9	89.3	1.0	8	92.8	3.5	3.9	103.9
10	133.4	0.5	4	125.8	- 7.6	-5.7	94.3
11	130.3	0.5	6	122.1	- 8.2	-6.3	93.7
12	124.9	0.5	8	132.0	7.1	5.7	105.7
13	126.8	0.75	4	124.3	- 2.5	-2.0	98.0
14	121.0	0.75	6	118.0	- 3.0	-2.5	97.5
15	120.5	0.75	8	132.1	11.6	9.6	109.6
16	120.4	1.0	4	114.3	- 6.1	-5.1	94.9
17	126.0	1.0	6	122.8	- 3.2	-2.5	97.5
18	134.2	1.0	8	129.6	- 4.6	-3.4	96.6
19	221.8	0.5	4	226.5	4.7	2.1	102.1
20	223.5	0.5	6	214.6	- 8.9	-4.0	96.0
21	220.1	0.5	8	223.2	3.1	1.4	101.4
22	224.0	0.75	4	213.9	-10.1	-4.5	95.5
23	220.4	0.75	6	225.8	5.4	2.5	102.5
24	229.8	0.75	8	228.4	- 1.4	-0.6	99.4
25	219.1	1.0	4	200.0	-19.1	-8.7	91.3
26	219.8	1.0	6	206.5	-13.3	-6.1	93.9
27	212.3	1.0	8	219.2	6.9	3.3	103.3
				Average Percent Difference		1.51	
				Average Absolute Percent Difference		6.39	
				Average Percent Recovery			101.51

*Contaminated probe.

In an effort to prove that the two large errors were a result of a contaminated probe and to test the ability of the audit system to withstand shipping through common mail, nine (9) samples were mailed to EPA in Research Triangle Park, North Carolina from the testing laboratory in Raleigh, North Carolina. EPA then returned the samples to the testing laboratory where they were introduced into a Method 5 sampling train equipped with an 8-foot probe. As shown in Table III, the results for the samples that were mailed to EPA and returned were all within 10 percent (15 mg) of the audit value. Based on these results, it was decided to proceed with Phase II of the program.

PHASE II - FIELD USE BY SINGLE LABORATORY

The second phase of the audit material development program assesses whether the audit material will provide acceptable results under field conditions and checks its stability. This phase is directed by the laboratory that has developed the prototype audit material, but the field test is conducted by personnel not directly involved in the development of the prototype. Since the audit is conducted by individuals not familiar with the audit material, the use of most audit materials requires written procedures that include the necessary data sheets.

In the case of the Method 5 audit material, fifty-seven (57) Method 5 audit materials were constructed and charged with particulate matter. Six were then selected from the 57 (2 from each of three different weight groups) and a laboratory accuracy check was conducted by transferring the contents of each device to a beaker and weighing. The results for these six materials are shown in Table IV and demonstrate acceptable recovery. The six audit materials tested were recharged and returned to the sample repository.

The written audit procedures were evaluated during two preliminary field audits conducted by a single laboratory. The audit results were within 10 percent of the audit value, and no problems were encountered with the written procedures. The stability of the audit system was evaluated using six of the 57 audit materials. These audit materials were held for six months and were then recovered using the Method 5 audit procedures. The recovery results for the six-month stability check are presented in Table V and indicate that the audit materials are stable over at least a six-month period.

Table III. Recovery Efficiencies Following Shipping of Method 5 Audit Device Charged With Fly Ash.*

Run No.	Flow Rate (cfm)	Audit Sample Weight (mg)	Combined Weight (mg)	Relative Difference (mg)	Percent Difference	Recovery (%)
1	0.5	75.5	87.7	12.2	16.2	116.2
2	0.75	74.6	81.2	6.6	8.8	108.8
3	1.0	76.6	86.9	10.3	13.4	113.4
4	0.5	124.1	116.4	-7.7	-6.2	93.8
5	0.75	126.5	118.4	-8.1	-6.4	93.6
6	1.0	122.3	118.0	-4.3	-3.5	96.5
7	0.5	225.5	213.6	-11.9	-5.3	94.7
8	0.75	225.1	231.8	6.7	3.0	103.0
9	1.0	221.5	214.9	-6.6	-3.0	97.0

*Using 8 ft. probe.

Table IV. Results for Laboratory Accuracy Check of Method 5 Audit Device Charged With Fly Ash.

Audit Device No.	Audit Value (mg)	Measured Value (mg)	Recovery (%)
7	80.4	84.0	104.5
10	76.3	77.7	101.8
23	128.1	131.0	102.3
25	133.4	134.1	100.5
42	232.2	232.8	100.3
43	233.6	232.3	99.4

Table V. Results of Audit Sample Stability Check.

Audit Device No.	Audit Value (mg)	Measured Value (mg)	Recovery (%)
5	79.7	78.6	98.6
6	71.3	72.3	101.4
9	76.4	76.3	99.9
29	128.8	127.9	99.3
45	234.5	230.5	98.3
47	235.5	234.2	99.4

PHASE III - INTERLABORATORY FIELD USE

Phase III evaluates the suitability of the audit material for field use. For the Method 5 audit material, five source sampling companies independently used the candidate Method 5 audit materials. The results of the audits are shown in Table VI. Standard statistical procedures were used to calculate the percent difference, the absolute percent difference, the percent recovery, the means, and the standard deviations.

Table VI. Results of Interlaboratory Field Audits.

Device No.	Audit Value (mg)	Measured Value (mg)	Difference (mg)	Percent Difference	Recovery (%)
14*	80.7	82.0	+ 1.3	+ 1.6	101.6
15	82.1	103.4	+21.3	+25.9	125.9
22*	132.0	120.4	-11.6	- 8.8	91.2
26	132.9	119.5	-13.4	-10.1	89.9
50	230.9	230.9	0.0	0.0	100.0
51	233.2	226.5	- 6.7	- 2.9	97.1
	Mean		-1.52	0.95	100.95
	Standard Deviation		12.6538	13.08	13.08
	Mean (of Absolute Value)				8.22
	Standard Deviation			9.55	

*Same laboratory.

The results were expected to be within 10 percent of the audit value. The reason for why the results for audit device No. 15 were outside of this range is not known. Based on the results of Phase I, it is likely that this value was in excess of the expected recovery because of a contaminated sampling system. However, there is no apparent bias in the audit system based on these results and the Phase I audit results as demonstrated by the mean of the difference between the measured values and the audit values (-1.52 mg).

As previously stated, a performance audit is conducted to determine quantitatively that a measurement system is in control. The high bias of some audits in Phase I and Phase III of the Method 5 audit material development program indicate that a significant procedural problem may exist with the cleaning of the Method 5 sample train prior to sampling. Apparently, the pre-cleanup procedures were not sufficient to avoid contamination of the audit sample in several of the performance audits. The number of occurences of this problem can be reduced by making the source test community more aware of the possibility of sample train contamination so that they can take corrective action.

PHASE IV - FIELD USE BY THE SOURCE SAMPLING COMMUNITY

The final phase evaluates the field use of the audit system by the source sampling community in general. The purposes of this phase are to demonstrate that they can use the audit system, and to create a data base for determining the acceptable range for audit results. As previously noted, the acceptable audit results range is set at a level that will guarantee that if a tester correctly follows all the procedures of the method, an acceptable audit result will be obtained. If an acceptable audit result is not obtained, the tester knows that he has made a procedural error and must evaluate his execution of the method. It is important to remember that the audit results are not intended to adjust the values of the field data, but rather to demonstrate that the sampling and analysis is being performed properly.

At the time this paper was written, we had not yet begun Phase IV of the development of the Method 5 audit system. However, it will follow the general procedures described below. The audit system will be included in the round robin audit program that EPA has conducted for several years. There are approximately 150 participants in this program, which generally represent the nation's sampling and analytical firms. The results of this performance audit of the source sampling community will be used to assess the suitability of the audit system and to calculate the acceptable range for audit results.

AUDIT MATERIALS PRESENTLY AVAILABLE FROM U. S. EPA[1]

The preparation and distribution of all audit materials are coordinated by the Quality Assurance Division of the Environmental Monitoring System Laboratory, Research Triangle Park, NC. The audit materials are available to all federal, state, and local agencies in support of performance audits for all enforcement testing. The audit materials are generally not available for internal audits by the private sector, except when requested by a federal, state, or local agency. However, the audit materials are available to contractors of government agencies. To request information about all source audit materials, except gas cylinders, write to:

Ms. Ellen Streib
Quality Assurance Division, MD-77B
Environmental Monitoring Systems Laboratory
Research Triangle Park, NC 27709
Commercial: (919) 541-7834
FTS: 629-7834

Audit gas cylinder samples can be obtained by contacting:

Mr. Robert Lampe
Quality Assurance Division, MD-77B
Environmental Monitoring Systems Laboratory
Research Triangle Park, NC 27711
Commercial: (919) 541-4531
FTS: 629-4531

The available audit materials are shown in the following three tables. Table VII lists the available single component organic gas audit cylinders and Table VIII lists the available multicomponent organic gas audit cylinders. Table IX describes the solid samples, aqueous samples, inorganic gases, and other audit materials available. The audit materials should be requested at least sixty (60) days prior to their actual need to ensure they will arrive in time.

REFERENCES

1. Von Lehmden, D. J. and W. G. DeWees. "Section 3.0.8 - Audit materials available from U. S. EPA." From Quality Assurance Handbook for Air Pollution Measurements, Volume III - Stationary Source Specific Methods, EPA 600/4-77-027b, November 1985.

Table VII. Single Component Level Organic Audit Cylinders Available From The U. S. EPA

Compound[a]	Low Concentration Range (ppm)	High Concentration Range (ppm)
Benzene	5-20	60-400
Ethylene	5-20	300-700 3000-20,000
Propylene	5-20	300-700
Methane/Ethane	---	1000-6000(M) 200-700(E)
Propane	5-20	300-700
Toluene	5-20	300-700
Hydrogen Sulfide	5-40	100-700
Meta-Xylene	5-20	300-700
Methyl Acetate	5-20	300-700
Chloroform	5-20	300-700
Carbonyl Sulfide	5-20	100-400
Methyl Mercaptan	3-10	-------
Hexane	20-80	1000-3000
1,2-Dichloroethane	5-20	100-600
Cyclohexane	----	80-200
Methyl Ethyl Ketone	30-80	--------
Methanol	30-80	--------
1,2-Dichloropropane	5-20	300-700
Trichloroethylene	5-20	100-600
1,1-Dichloroethylene	5-20	100-600
Perchloroethylene	5-20	300-700
Vinyl Chloride	5-30	--------
1,3-Butadiene	5-50	--------
Acrylonitrile	5-20	300-700
Methyl Isobutyl Ketone	5-20	75
Ethylamine	5-20	------
Methylene Chloride	1-20	------
Carbon Tetrachloride	5-20	------
F-113[b]	5-20	------
Methyl Chloroform	5-20	------
Ethylene Oxide	5-20	------
Propylene Oxide	5-20	75-200
Allyl Chloride	5-20	75-200
Acrolein	5-20	75-200
Chlorobenzene	5-20	------
Carbon Disulfide	--	75-200
EPA Method 25 Gas[c]	100-200	750-2000
Ethylene Dibromide	5-20	75-400
1,1,2,2-Tetrachloroethane	5-20	------

[a] All organic compounds in audit cylinders are in a balance of N_2 gas.

[b] F-113 is the compound 1,1,2-trichloro 1,2,2-trifluoroethane.

[c] Contains an aliphatic, an aromatic and carbon dioxide in nitrogen. Concentrations shown are reported in ppmC.

Table VIII. Multicomponent Organic Audit Cylinders Available From the U. S. EPA.

Group	Concentration Range of Each Compound (ppb)
Group I*	7-90 90-430 430-10,000
Group II**	7-90 90-430
Group III***	7-90 90-430
Group IV****	7-90 430-10,000

* Group I Compounds are carbon tetrachloride, chloroform, perchloroethylene, vinyl chloride, and benzene in a balance of N_2 gas.

** Group II Compounds are trichloroethylene, 1,2-dichloroethane, 1,2-dibromoethane, acetonitrile, trichlorofluoromethane (F-11), dichlorodifluoromethane (F-12), bromomethane, methyl ethyl ketone, and 1,1,1-trichloroethane in a balance of N_2 gas.

*** Group III Compounds are vinylidene chloride, 1,1,2-trichloro 1,2,2-trifluorethane (F-113), 1,2-dichloro 1,1,2,2-tetrafluorethane (F-114), acetone, 1-4 dioxane, toluene, and chlorobenzene in a balance of N_2 gas.

**** Group IV audit cylinders are under development, and will be available about December 1986. Group IV compounds are acrylonitrile, 1,3-butadiene, ethylene oxide, methylene chloride, propylene oxide and ortho-xylene.

Table IX. Solid, Liquid, and Inorganic Gases and Other Audit Materials Available From the U. S. EPA.

Material	Description
SO_2 and CO_2 Gas Samples	SO_2 and CO_2 in a balance of N2 are contained in gas cylinders in a range of 200 to 400 ppm SO_2 and 12 to 16% CO_2 for auditing EPA Method 6B
CO_2, O_2, and CO Gas Samples	CO_2, O_2, and CO are contained in a pressurized canister; one canister per set with range of 5 to 8% for CO_2, 10 to 15% for O_2, and 0.5 to 4% for CO
Calibrated Orifices	Calibrated critical orifices in either of two standard quick connects to check both rate and volume meters at 0.5 to 1.0 cfm for auditing EPA Methods 5, 5A, and 5D
SO_2 Samples*	Aqueous sulfuric acid solution in glass ampoules; two per set in three ranges with normal values of 750, 1500, and 2500 mg of SO_2 per dscm for auditing EPA Methods 6, 6A, and 6B
NO_x Samples*	Aqueous potassium nitrate solution in glass ampoules; two per set in three ranges with nominal values of 450, 900, and 1750 mg of NO_2 per dscm for auditing EPA Methods 7, 7A, 7C, and 7D
Sulfuric Acid Samples*	Same as the SO_2 samples; use for auditing EPA Method 8
Inorganic Lead Samples	Lead salts impregnated on a glass fiber filter in the range of 100 to 600 µg and 900 to 2000 µg of lead per audit sample for auditing EPA Method 12
Total Fluoride Samples*	Aqueous sodium fluoride in Nalgene^R bottle; two per set in the ranges of 0.2 to 1.0 mg of fluoride per dscm and 1 to 5 mg of fluoride per dscm for auditing EPA Methods 13A and 13B
Coal Samples	Coal samples with known quantities of Btu's per pound, %S content, and moisture content; two per set in the range of 11,000 to 14,500 Btu's per pound for heating value, 0.5% to 4% for sulfur content, and 2% to 12% moisture content for auditing EPA Method 19
Mercury Samples*	Aqueous mercury chloride in glass ampoules; two per set in the ranges of 5 to 20 µg of mercury per ml and 50 to 100 g of mercury per ml of sample for auditing EPA Methods 101, 101A, 102, and 105

(continued)

Table IX. (continued)

Material	Description
Arsenic Samples*	Aqueous arsenic salts in glass ampoules; one per set in the range of 10 to 50 µg/ml or 100 to 500 µg/ml of arsenic for auditing EPA Methods 108 and 108A
Beryllium Samples*	Aqueous beryllium salts in glass ampoules; two per set in the ranges of 5 to 20 µg of beryllium per audit sample and 50 to 100 µg of beryllium per audit sample for auditing EPA Method 104

* Aqueous audit samples can be reduced to known concentration less than the stated range by taking smaller aliquots and/or by dilution.